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PERMIAN CORALS FROM THE SPRING MOUNTAINS, NEVADA

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ABSTRACT—Rugose and tabulate corals from the Lower Permian (Wolfcampian, Leonardian) Bird Spring Group in the Lee Canyon section of the Spring Mountains, Clark County, Nevada, are referred to eight genera and ten species. New taxa are *Fomichevella nevadensis* n. sp., *F. waltersi* n. sp., *Mccloudius parvus* n. sp., and *Paraheritschioides richi* n. sp. The fauna is most similar to the shelf fauna in eastern Nevada, but there are significant similarities to corals from the Antler Highland embayments of central Nevada and southern Idaho and to faunas of the same age in northern California and northern British Columbia. The paleogeography is interpreted as shallow water near the east side of the mouth of a south-opening coastal sea, bordered on the east by the continent and on the west by the Antler Highland. Corals migrated south along the western shores of the Antler Highland and mixed with the shelf fauna, perhaps with some corals crossing from Tethys to the coast. The modern eastern Pacific tropical coral faunas, which have several hermatypic coral genera and species derived from the western Pacific in the Pleistocene, may occupy a somewhat similar geography near the mouth of the modern Gulf of California.

INTRODUCTION

THIS STUDY reports the stony coral fauna from the Lower Permian part of a thick section in the northern Spring Mountains, Clark County, Nevada. The section is north of Lee Canyon and has become important because the fusulinid fauna from it was reported relatively early (Rich, 1961). Investigation of the coral fauna was undertaken chiefly to determine whether or not it might shed some light on the diverse and seemingly isolated coral subprovinces of western North America, considered by some workers to be evidence for formerly widespread terranes.

PREVIOUS WORK

Rich (1960) first noted this section in a report of a Pennsylvanian *Chaetetes*. Later, Rich (1961) described the section more than 7,000 feet (2,134 m) in thickness north of Lee Canyon from which the *Chaetetes* was collected and referred it to the Bird Spring Formation. He figured and identified the fusulinids from the Morrowan (Pennsylvanian) to Leonardian (upper Lower Permian) stages. The non-fusulinid bearing part of the section ranges downward to the Upper Mississippian (Chesterian). Later, Rich (1963, 1964, 1969) included data obtained from the section in several studies on the petrography and in one report (Rich, 1962) on a terrestrial plant from the Mississippian part of the section. Barosh (1968) noted thick sandstone units in the upper part of the Lee Canyon section that were more similar to formations in east-central Nevada than to the Bird Spring Group (elevated from formational rank by Langenheim et al., 1962), suggested that correlation was possible using some corals and the lithology, and implied that use of the formational names Riepe Spring Limestone, Rib Hill Sandstone, and Arcturus Formation might be extended from east-central Nevada to the Lee Canyon section. This intriguing suggestion has not been subsequently followed and the Upper Pennsylvanian–Lower Permian part of the Bird Spring Group has not been divided into formal formations for a number of reasons. Therefore, formational names have not been applied to the lithologic units in this study.

REGIONAL GEOLOGY

The Spring Mountains are in the Basin and Range Geomorphic Province, an area of generally north-south trending, block-faulted mountain ranges separated by valleys. Sedimentary rocks representing some Precambrian, all of the Paleozoic, and part of the Mesozoic are present. Paleozoic marine sedimentary rocks predominate. Major NE-SW trending thrust faults and generally EW trending strike-slip faults affect palinspastic restoration of the study area. Stewart (1980) described the regional geology of Nevada and Longwell et al. (1965) that of Clark County, which includes the Spring Mountains. Burchfiel et al. (1974) mapped and discussed the geology of the Spring Mountains.

STRUCTURE AND RELATIONSHIPS

The Lee Canyon section occurs in a generally NW dipping block with beds dipping from 25 to 40 degrees. It has normal faults of minor displacement and is truncated by a larger normal fault (Rich, 1961). Higher parts of the Lower Permian occur northeast of the fault at the top of the Lee Canyon section and include coral-bearing beds.

STRATIGRAPHY, AGE, AND CORRELATION

The Permian part of the Lee Canyon section is 1,616 m thick (Figure 1). As first recognized by Barosh (1968), it has three lithologic units: a lower limestone sequence (238 m thick), a central sandstone sequence with some thin limestone beds (1,037 m thick), and an upper sandstone–limestone sequence (341 m thick). The Lee Canyon section begins with the occurrence of the lowest colonial rugose coral (LACMIP loc. 1255), which occurs in the lower part of the Zone of *Pseudoschwagerina* and slightly above the occurrence of *Triticites creekensis* as cited by Rich (1961), a species described by Thompson (1954) from the Camp Creek Shale (Permian) near Santa Ana, Texas. This species was used by Cassity and Langenheim (1966) to define the base of the Wolfcampian in the Arrow Canyon Range of eastern Clark County, Nevada, a usage extended here to the Lee Canyon section.

The middle sandstone sequence lies entirely within the Zone of *Pseudoschwagerina*. Mills and Langenheim (1987) cited lithologic similarities of Rich's (1961) description of this sequence to the "platy limestone member" of the Wamp Spring section in the Las Vegas Range to the northeast.

The upper sandy limestone sequence has a primitive *Parafusulina* sp. at about 150 m above the contact with the sandy sequence and therefore indicates the Zone of *Parafusulina* and the Leonardian Series. This is strengthened by the occurrence of *Schwagerina gumbeli* and *S. crassitectoria* in several overlying beds, two species placed in the Zone of *Parafusulina* of the Great Basin by Brill (1963).

The coral genera and species are typical of the western North American Lower Permian, with the exception of the three new species for which geographic and stratigraphic ranges are as yet

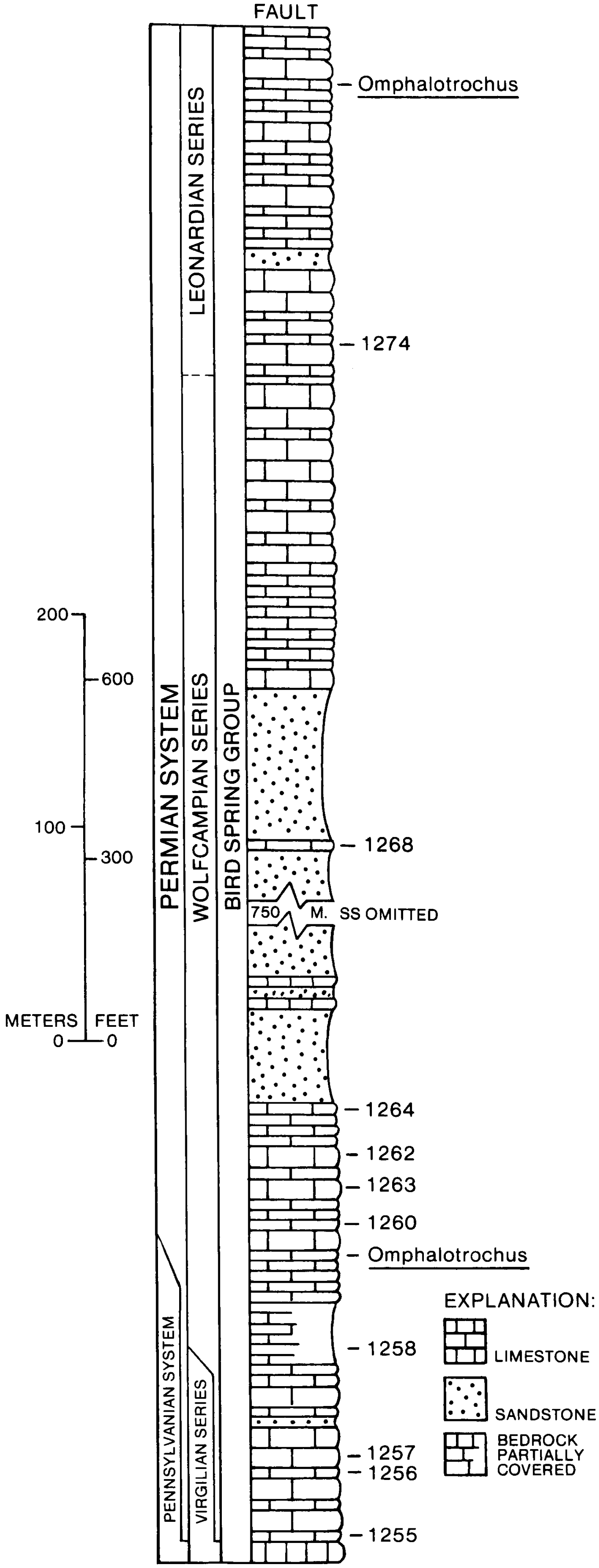

FIGURE 1—Columnar section of Permian part of Bird Spring Group in Lee Canyon section of this paper, showing localitions of coral collections (numbers) and occurrences of the gastropod *Omphalotrochus*.

unknown. The correlation of the corals with other formations is discussed in the following section.

OCCURRENCE AND COMPARISON OF RELATED PERMIAN CORAL FAUNAS

Figure 2 summarizes the common occurrences of the Lee Canyon Permian corals with some other important Permian coral faunas from western North America. The Lee Canyon coral fauna is most closely related to the Early Permian coral fauna of the shelf area in east-central and southeastern Nevada. The shelf faunas were described chiefly by Easton (1960), McCutcheon and Wilson (1961), Wilson and Langenheim (1962), Langenheim and Langenheim (1965; an important list), and Stevens (1967). There are five species in the Lee Canyon section that also occur in the eastern Nevada shelf fauna, and they occur in the same stratigraphic sequences in both areas.

Corals from the Antler Highland embayments of north-central Nevada have not been studied extensively, although Hoare (1964, 1966) described corals from the Sunflower Formation and Sando (1985) described a coral from the Upper Pennsylvanian Oquirrh Formation of Power County, southern Idaho, that may have been deposited in an embayment on the eastern side of the Antler Highland. *Cornwallatia tabularia* (Hoare, 1964) from the Sunflower Formation also occurs in the Lee Canyon section and has not been reported elsewhere. *Paraheritschioides* Sando, 1985, was originally described from the Oquirrh Formation. A new species of this genus occurs in the Lee Canyon section. These two taxa correlate the Lee Canyon section corals to the Antler Highland embayment fauna.

Permian corals of the eastern Klamath Mountains, northern California area, were described chiefly by Meek (1864), Langenheim and McCutcheon (1959), Wilson (1982), Wilson (1985), and Stevens et al. (1987). Corals of the Lee Canyon section share two tabulate species and two rugose genera with the McCloud Limestone of the eastern Klamath Mountains. One of the genera (*Mccloudius*) is reported outside the type locality for the first time. This correlation is strengthened by the occurrence of other corals of the McCloud Limestone in the eastern Nevada and Antler Highland faunas.

Stevens and Rycerski (1989) described the Early Permian coral fauna of the Stikine River area, British Columbia, Canada. Two genera from their fauna also occur in the Lee Canyon fauna, suggesting a correlation as well as being the southernmost reported occurrence of these genera.

In summary, the Lee Canyon fauna is part of the shelf fauna that includes eastern Nevada, but it has significant elements in common with faunas of the Antler Highland embayments, the northern California formations, and northern British Columbia.

Magginetti et al. (1988) reported a mixture of fusulinid faunas of the Texas-Cordilleran region and the eastern Klamath Mountains in the Lower Permian Owens Valley Group of east-central California. Nassichuk and Wilde (1977) had already extended the range of significant fusulinid species and zones from the fusulinid fauna of the eastern Klamath Mountains originally described by Skinner and Wilde (1965) to southwestern Ellesmere Island in the Canadian Arctic Archipelago. The mixture of these two very widespread fusulinid faunas in the Owens Valley Group is of a magnitude of significance equal to that of the mixing of the coral faunas reported in the present study.

Perhaps a somewhat comparable uniformitarian example ex-

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corals \ areas	NW BRITISH COLUMBIA, STIKINE RIVER AREA	EASTERN KLAMATH MOUNTAINS	ANTLER HIGHLAND EMBAYMENTS	EASTERN NEVADA	THIS PAPER
FOMICHEVELLA spp.	X				X
KLEOPATRINA FTATATEETA				X	X
PARAHERITSCHIOIDES spp.	X	X	X?		X
DIPHYPHYLLUM CONNORSENSIS				X	X
THYSANOPHYLLUM PRINCEPS				X	X
MCCLOUDIUS spp.		X			X
SYRINGOPORA MCCUTCHEONAE		X		X	X
SYRINGOPORA MULTATTENUATA		X		X	X
CORNWALLATIA TABULARIA			X		X

FIGURE 2—Occurrences of Permian corals in the Lee Canyon section of this paper and in other areas of western North America.

ists in the modern eastern Pacific, where the tropical hermatypic coral fauna of the Gulf of California is separated by the Baja California peninsula from the temperate coral fauna of the Pacific Ocean on the peninsula's west coast, with mixing of the two faunas around the southern end of the peninsula. In this analogy, the Lee Canyon fauna would have existed near the south end of the eastern sea, east and perhaps south of the Antler Highland, and the northern California to British Columbia faunas to the west of the Antler Highland, at least in part. Full oceanic access, as with the modern Gulf of California, would have been possible around the southern end of the Antler Highland, permitting faunal mixing. The sea east of the Antler Highland extended a great distance north, at least into British Columbia and perhaps farther.

Many elements (genera and species) of the modern hermatypic fauna of the Gulf of California and the entire eastern Pacific migrated there from the western Pacific in the Pleistocene (most recently summarized by Glynn and Wellington, 1983). Living corals are known to be dispersed great distances in the modern Pacific Ocean, both by larval dispersal in the plankton and rafting on floating objects (e.g., pumice). Jokiel (1984, 1989) studied examples of the latter, some involving reproductively mature coralla, which he suggested may have traversed a total distance of 20,000 to 40,000 km and could have completed several circuits of the tropical and subtropical Pacific basin. As one reviewer commented (Jokiel, 1984, p. 116) about the apparent rarity of rafting, "Two events in 4–5 years equals 400,000 times per million years!"

Perhaps a similar Permian dispersal might account for a few western North American occurrences of the typically Tethyan Permian corals reported by Stevens et al. (1987), a distribution now generally attributed chiefly to long distance terrane movement. The possibility for some migration into the eastern Pacific Permian faunas was first suggested by Newton (1988) on the basis of analogy with the well-known dispersal of modern mollusks across the Pacific Ocean from the western to the eastern Pacific.

PALEOECOLOGY

The fauna of the Permian part of the Lee Canyon section consists of encrusting calcareous algae, fusulinids, sponges, corals, bryozoans, brachiopods, several kinds of mollusks (including pectinid bivalves), echinoids, and crinoids. Of these taxa, only the sponges, bryozoans, and mollusks are known to occur in both fresh and marine waters. Fusulinids have not been reported from rocks of freshwater or brackish-water origin. Living corals, brachiopods, pectinids, and echinoderms are known only from marine environments. I saw no fossils indicative of a brackish, freshwater, or hypersaline environment in the Lee Canyon section. The entire fauna suggests normal salinity sea water.

Fusulinids occur throughout the section. Tasch (1957) considered that they lived in 5- to 50-foot depths (1.5–15 m). Thompson (1964) cited an offshore, open-water environment for them. Langenheim et al. (1977) noted several later viewpoints on fusulinid paleoecology, most of which are in general agreement with Tasch (1957) and Thompson (1964). More recently, Connolly (1987, p. 139) stated that "fusulinids favored shallow depths and estimates less than 100 feet seem reasonable." Wells (1957) considered Paleozoic colonial rugose corals to be indicative of well-oxygenated, gently circulating marine water with annual temperature minima of 16°–21°C. Sando (1980) used associations of corals and algae to determine depths of shallow-water corals, concluding that a maximum depth of 100 m was possible but less than 50 m more probable. Most paleogeographic maps show the Early Permian paleoequator

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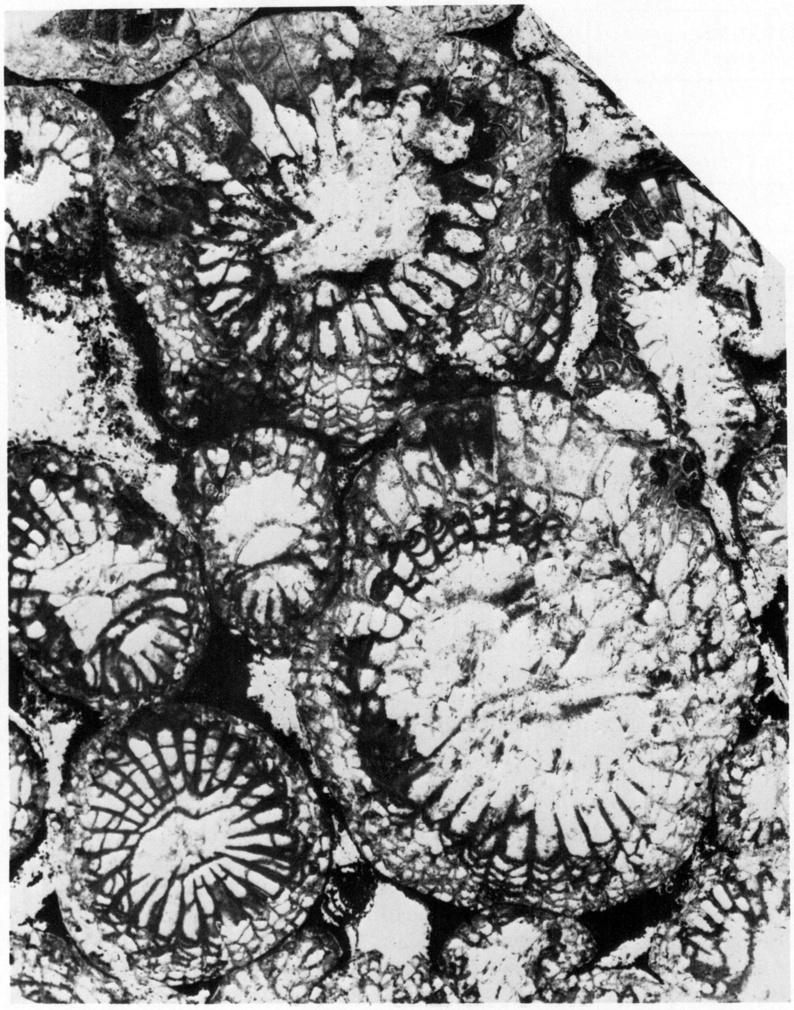
FIGURE 3—*1–3, Fomichevella nevadensis* n. sp., holotype LACMIP 8367. *1, 2,* transverse sections; *3,* longitudinal sections. *4, 5, Fomichevella waltersi* n. sp. *4,* transverse section, holotype LACMIP 8368; *5,* transverse sections, paratype LACMIP 8369. All figures ×3.

FIGURE 4—*Fomichevella waltersi* n. sp. *1,* transverse sections, holotype, LACMIP 8368; *2,* transverse sections, paratype LACMIP 8370; *3,* longitudinal sections paratype LACMIP 8370; *4,* transverse sections, paratype LACMIP 8369. All figures ×3.



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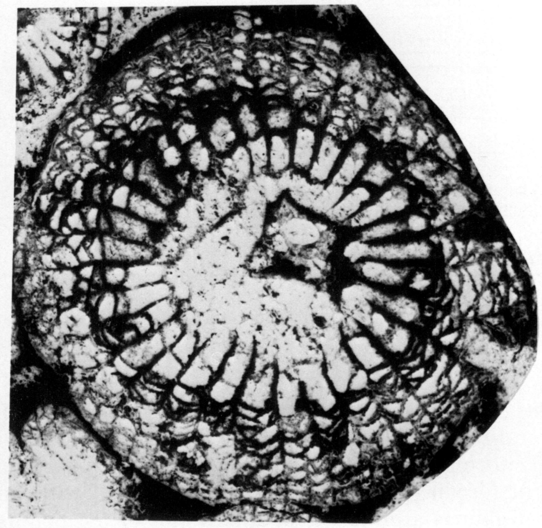

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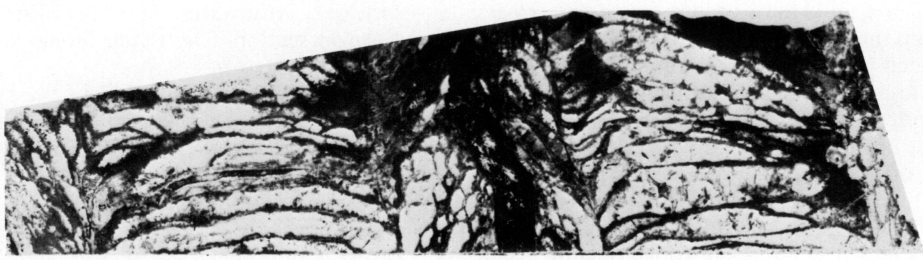

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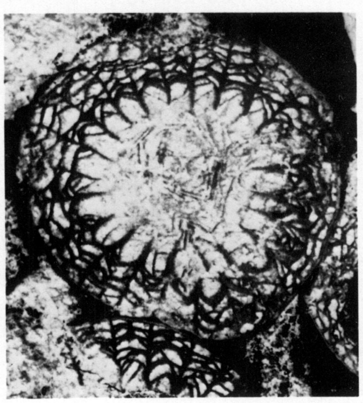

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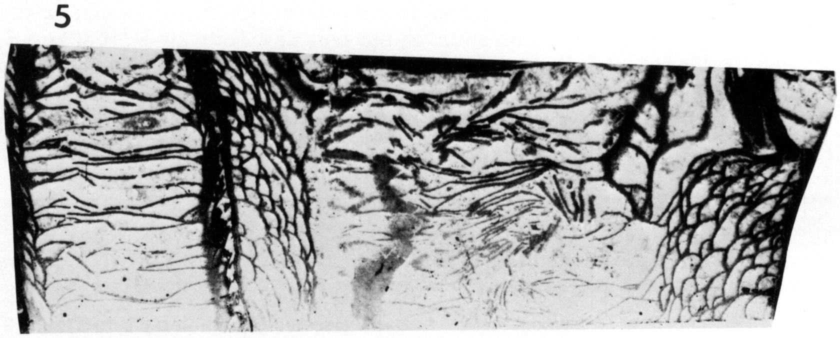

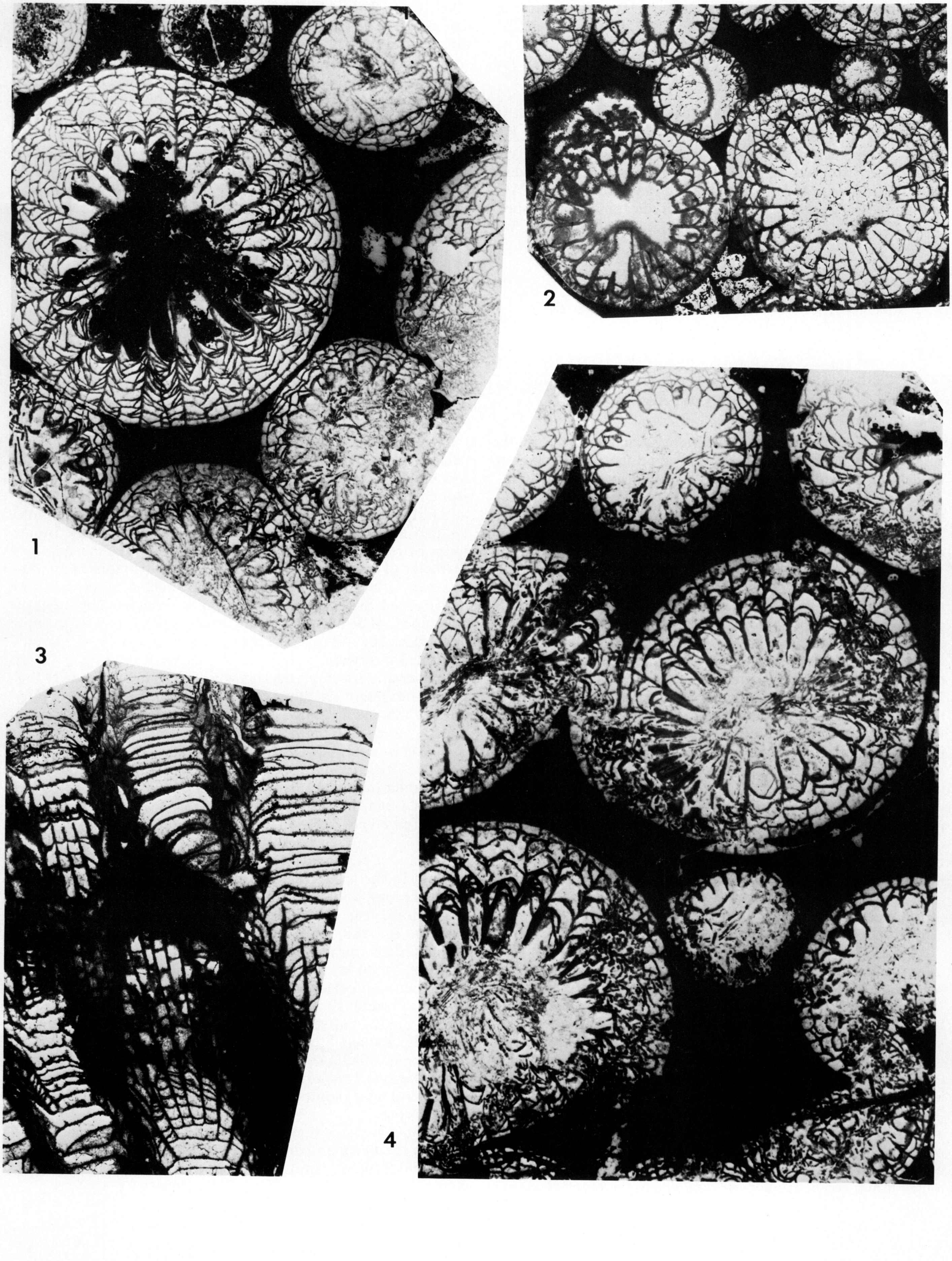
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somewhere within California or northern Mexico, indicating that the Lee Canyon section was deposited in tropical seas.

I conclude that the Lee Canyon section was deposited in clear, shallow, warm marine water of normal salinity and with full access to the open sea.

COLLECTIONS AND METHODS

Morphological terminology is from Hill (1981), with a few additional terms that are in widespread use. Locality and type numbers are from the Natural History Museum of Los Angeles County, Invertebrate Paleontology Section (abbreviated LACMIP). Locality descriptions are given in the appendix. All specimens are deposited in LACMIP. The University of California Museum of Paleontology is abbreviated UCMP.

SYSTEMATIC PALEONTOLOGY

Subclass RUGOSA Milne-Edwards and Haime, 1850
Order STAURIIDA Verrill, 1865
Suborder CANININA Wang, 1950
Family CYATHOPSIDAE Dybowski, 1873
Genus FOMICHEVELLA Fedorowski, 1975
FOMICHEVELLA NEVADENSIS n. sp.
Figure 3.1–3.3

Diagnosis.—A species of *Fomichevella* characterized by the combination of large corallites, very abundant septa, short to moderately long minor septa, and a wide dissepimentarium.

External description.—Corallum phaceloid, hemispheroidal, maximum observed diameter 14 cm; corallite diameter up to 23 mm; corallites closely crowded, most touching; epitheca and calices not observed.

Transverse section description.—Corallites circular to subcircular, diameters 13–23 mm, very closely spaced, generally touching to a few mm apart; septa of two orders, 25–36 each, straight to somewhat sinuous, generally thin in dissepimentarium, many dilate in tabularium, attenuate axially; major septa 6–7 mm long, protruding 2–3 mm into tabularium, except some cardinal septa 1–2 mm shorter; minor septa well developed, 2–3 mm long, generally crossing half-diameter of dissepimentarium, none penetrating tabularium; dissepimentarium regular, wide, with angular, concentric, and herringbone dissepiments; false wall stereozone present in some corallites; tabularium open, 8–16 mm wide, open space beyond tips of septa up to 12 mm wide; corallite wall about 0.3 mm wide.

Longitudinal section description.—Dissepimentarium of 3–9 ranks of steeply dipping, small and cystose or large and elongate dissepiments; tabulae flat to domed with flat tops and downturned edges, irregularly spaced, 10–14/cm, broken into tabellae in few places.

Collections.—LACMIP holotype 8367. Eight thin sections and 30 polished sections from one well-preserved corallum from LACMIP locality 1263 were studied.

Discussion.—*Fomichevella nevadensis* n. sp. falls into the group of species in the genus that have large corallites, numerous septa, and minor septa that do not cross the dissepimentarium. It shares these characters with *F. waltersi* n. sp. from much lower in the same section, but *F. nevadensis* has longer minor septa, more abundant major septa, and smaller corallites. Of the 16 other taxa referred (Fedorowski, 1975; Stevens and Rycerski, 1989) to the genus, only five are similar to *F. nevadensis* in some features. *Fomichevella uralicum* (Dobrolyubova, 1936), from Russia, has somewhat similar size corallites but more abundant septa and longer minor septa. *Fomichevella septentrionale* (Heritsch, 1939), from Spitsbergen, has similar size corallites and a somewhat similar number of septa, but much longer minor septa. *Fomichevella magna* Stevens and Rycerski, 1989, from British Columbia, has a similar number of septa and similar size corallites, but much longer minor septa and a much more obvious shortened cardinal septum. *Fomichevella southeri* Stevens and Rycerski, 1989, also from British Columbia, has a similar number of septa and similar size corallites, but the minor septa are much shorter than those of *F. nevadensis* and the shortened cardinal septum is more obvious. *Fomichevella bamberi* Stevens and Rycerski, 1989, likewise from British Columbia, also has a similar number of septa and similar size corallites, but its minor septa are longer than those of *F. nevadensis* and its shortened cardinal septum more obvious.

Etymology.—The species is named for the state of Nevada.

FOMICHEVELLA WALTERSI n. sp.
Figures 3.4–3.5, 4.1–4.4

Diagnosis.—A species of *Fomichevella* characterized by the combination of very large corallites, moderately abundant septa, short or moderately long minor septa confined to dissepimentarium, and a very wide dissepimentarium.

External description.—Corallum phaceloid, hemispheroidal, maximum observed diameter 20 cm; corallite diameter up to 33 mm, closely crowded, most touching; epitheca and calices not observed.

Transverse section description.—Corallites circular to subcircular, diameters 18–28 mm, very closely spaced, generally touching to a few mm apart; septa of two orders, 24–28 each, straight, thin in dissepimentarium, thin or somewhat dilate in tabularium; major septa 4–8 mm long, protruding 1–4 mm into tabularium, except some cardinal septa 1–2 mm shorter; minor septa extremely short or few extending to less than one-half diameter of dissepimentarium, never reaching tabularium; dissepimentarium regular, very wide, with angular, concentric, and herringbone dissepiments; false wall stereozone only slightly developed, if at all; tabularium open, 13–16 mm wide, with open space beyond tips of septa up to 5 mm wide; corallite wall about 0.3 mm wide.

Longitudinal section description.—Dissepimentarium of 3–8 ranks of different sized, mostly globose (some elongate) dissepiments; tabulae flat, with or without downturned edges, irregularly spaced, 10–16/cm; tabellae uncommon.

Collections.—LACMIP holotype 8368, LACMIP paratypes 8369–8378. Seven thin sections and 45 polished sections from two coralla (holotype, paratype 8369) from LACMIP locality 1255 and four thin sections and 37 polished sections from nine coralla (paratypes 8370–8378) from LACMIP locality 5645 were studied.

Discussion.—*Fomichevella waltersi* n.sp., like *F. nevadensis*, belongs in the group of species that have large corallites, numerous septa, and minor septa that do not cross the dissepimentarium. It is distinguished from *F. nevadensis* in the discussion for that species. The following species can be distinguished from *F. waltersi* as noted: *F. uralicum* (Dobrolyubova, 1936) has many more septa and longer minor septa; *F. septentrionale* (Heritsch, 1939) has smaller corallites and longer minor septa; *F. magna* Stevens and Rycerski, 1989, has a greater number of septa, smaller corallites, and longer minor septa; *F. southeri* Stevens and Rycerski, 1989, has somewhat more septa, smaller corallites, and more obvious shortened cardinal septa; *F. bamberi* Stevens and Rycerski, 1989, has somewhat more septa, somewhat smaller corallites, and much longer minor septa.

It should be noted that *F. waltersi* is the lowest colonial rugose coral in the Permian part of the Lee Canyon section, and that no colonial rugose corals were found in the underlying Pennsylvanian.

Etymology.—The species is named for Larry Walters, a volunteer field assistant on the April, 1969, field trip.

Suborder Lithostrotionia
Spassky and Kachanov, 1971
Family Durhaminidae Minato and Kato, 1965
Genus Kleopatrina McCutcheon and Wilson, 1963
Kleopatrina (Kleopatrina) ftatateeta
(McCutcheon and Wilson, 1961)
Figure 5.1–5.2

Ptolemaia ftatateeta McCutcheon and Wilson, 1961, p. 1025, Pl. 123, figs. 1–6; Wilson and Langenheim, 1962, Pl. 87, figs. 1, 2.
Kleopatrina wilsoni Minato and Kato, 1965, p. 69.

Documentation.—LACMIP hypotype 8379. Two thin sections and 26 polished sections from one corallum from LACMIP loc. 1264 were studied.

Discussion.—This elegant little coral is widespread in eastern Nevada at least from the Egan Range in east-central Nevada to the Arrow Canyon Range in southeast Nevada. The Spring Mountains occurrence extends the geographic range to the southwest part of the state. In east-central Nevada it occurs only in the narrow stratigraphic interval with *Thysanophyllum princeps* and *Syringopora mccutcheonae.* In the Arrow Canyon Range it occurs in the same unit with *Syringopora mccutcheonae* (Langenheim and Langenheim, 1965). In the Spring Mountains these three species occur in separate units, all of which are in a limestone sequence below thick sandstone beds, as in east-central Nevada.

Minato and Kato (1965) erected *Kleopatrina* (*K.*) *wilsoni* for a paratype of *K. ftatateeta* from Arrow Canyon, noting that McCutcheon and Wilson (1961) considered morphological features of this paratype to be variants within the species. At the same time, Minato and Kato (1965) referred figure 5 of McCutcheon and Wilson (1961) to *K. ftatateeta,* clearly noting that it was a photograph from a thin section of UCMP paratype 30268, their holotype of *K. wilsoni.* This demonstrates that features of the two species occur in the same corallum, invalidating the concept of *K. wilsoni.*

Family Heritschioidae Sando, 1985
Genus Paraheritschioides Sando, 1985
Paraheritschioides richi n. sp.
Figure 5.3–5.8

Diagnosis.—A species of *Paraheritschioides* characterized by the combination of relatively small corallite diameters; minor septa generally confined to dissepimentarium; axial ends of major septa dilated; generally thick false wall; and generally small dissepiments in longitudinal section.

External description.—Corallum phaceloid, hemispheroidal, maximum observed diameter 12 cm; corallites to 10 mm diameter, touching to 15 mm apart; epitheca and calices not observed.

Transverse section description.—Corallites circular to subcircular, diameters 7–10 mm; septa of two orders, 19–23 each, thin in dissepimentarium, moderately dilate in tabularium; major septa 2–4 mm long, protruding 1–3 mm into tabularium; major septa 2–4 mm long, protruding 1–3 mm into tabularium, except some cardinal septa 1–2 mm shorter, and counter septa that may be attached to axial structure; minor septa extremely short, generally confined to dissepimentarium, few entering tabularium as nubs; dissepimentarium generally regular, incompletely circling some corallites, lonsdaleoid in small parts of some corallites, about 1 mm wide, with angular, concentric, herringbone, and pseudoherringbone dissepiments; false wall stereozone pronounced in most corallites; axial structure generally simple, clisiophylloid, consisting of somewhat dilate medial plate and one or few more septal lamellae, may be attached to counter septum and, in some, a few other septa; corallite wall about 0.3 mm wide.

Longitudinal section description.—Dissepimentarium of 1–5 ranks of dissepiments, different sizes, generally small and globose, steeply inclined; tabellae of two generally poorly defined ranks, axial and periaxial; axial tabellae of 1–2 ranks, steeply inclined inwards and upwards to medial plate; periaxial tabellae straight to somewhat domed, horizontal or gently inclined inwards and upwards to periaxial tabellae; medial plate continuous, somewhat sinuous.

Collections.—Holotype, LACMIP 8380; paratypes, LACMIP 8381–8387. Seven thin sections and 45 polished sections from eight coralla from LACMIP locs. 1264 (paratypes 8384–8387) and 1268 (holotype, paratypes 8381–8383) were studied.

Discussion.—Species of *Paraheritschioides* have previously been reported from the Upper Pennsylvanian Oquirrh Formation of Idaho, the Lower Permian McCloud Formation of northern California (Sando, 1985), and unnamed Lower Permian formations from the Stikine River area of British Columbia (Stevens and Rycerski, 1989). The species form a morphologically similar group with corallite diameters ranging from 6.8 to 12.5 mm and major septa numbering from 18 to 28. Speciation is largely confined to the size and complexity of the axial structure and some characters that would seem rather minor in many other genera. *Paraheritschioides richi* fits into this group and is distinguished by similar characters.

Paraheritschioides richi has smaller corallites than *P. grandis* Sando, 1985, and *P. jennyae* Stevens and Rycerski, 1989, from the Upper Pennsylvanian Oquirrh Formation of Idaho and the Lower Permian of British Columbia, respectively. It has a simpler axial structure than *P. complexa* Sando, 1985, from the Upper Pennsylvanian Oquirrh Formation of Idaho. It has a simpler axial structure and much shorter minor septa than *P. wickenae* Stevens and Rycerski, 1989, from the Lower Permian of British Columbia. *Paraheritschioides richi* is most similar to *P. stevensi* (Wilson, 1982) from the Lower Permian McCloud Limestone of northern California, but *P. richi* has much more dilate septa in the tabularium, a thicker false wall stereozone, and generally less inflated dissepiments. *Paraheritschioides richi* also appears to have more lonsdaleoid parts to the predominately regular dissepimentarium than other species.

Etymology.—The species is named for Mark Rich.

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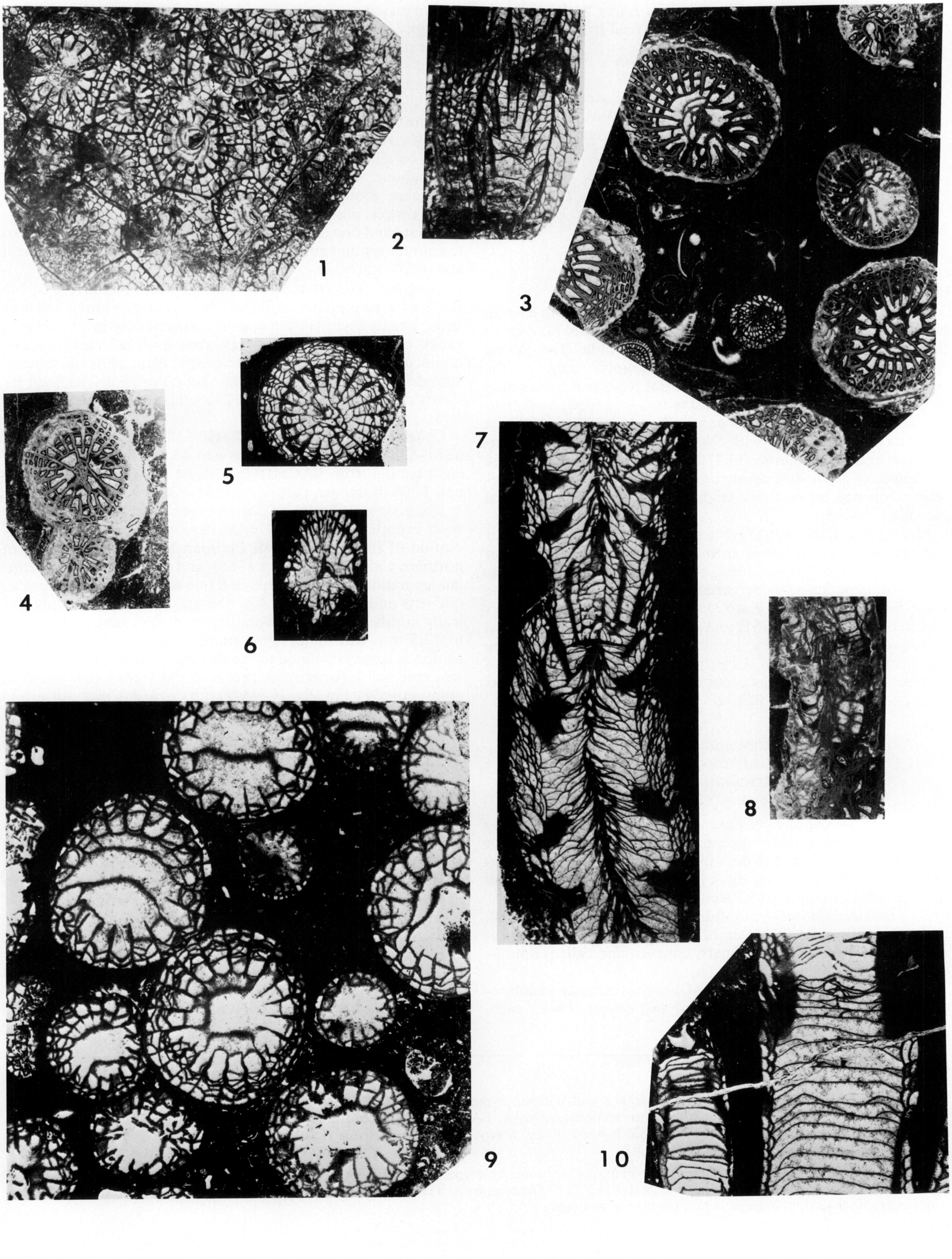
Figure 5—*1, 2, Kleopatrina ftatateeta* (McCutcheon and Wilson), hypotype, LACMIP 8379. *1,* transverse section; *2,* longitudinal section. *3–8, Paraheritschioides richi* n. sp. *3, 4,* transverse sections, holotype, LACMIP 8380; *5, 6,* transverse sections, paratype, LACMIP 8381; *7, 8,* longitudinal sections, paratypes, LACMIP 8382, 8383. *9, 10, Diphyphyllum connorsensis* (Easton), hypotype, LACMIP 8388. *9,* transverse section, *10,* longitudinal section. All figures ×3.

Figure 6—*1–4, Mccloudius parvus* n. sp. *1, 2,* transverse sections, holotype, LACMIP 8390; *2,* ×6; *3,* longitudinal section, paratype, LACMIP 8391; *4,* transverse section, paratype, LACMIP 8392. *5, 6, Thysanophyllum princeps* (Easton), hypotype, LACMIP 8389. *5,* transverse section; *6,* longitudinal section. Figures ×3 unless otherwise noted.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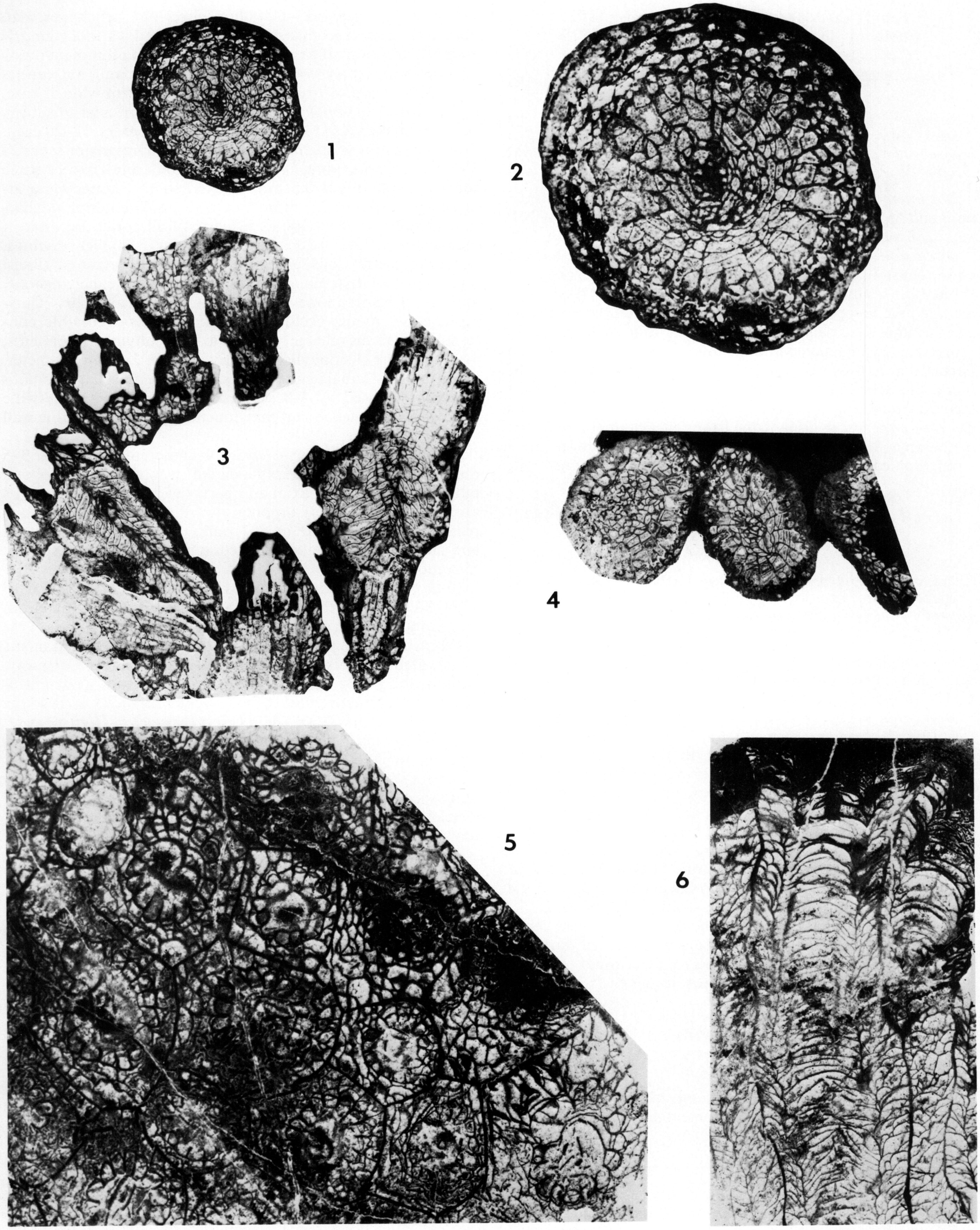
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Family LITHOSTROTIONIDAE d'Orbigny, 1852
Subfamily DIPHYPHYLLININAE Dybowski, 1873
Genus DIPHYPHYLLUM Lonsdale, 1845
DIPHYPHYLLUM CONNORSENSIS (Easton, 1960)
Figure 5.9–5.10

Lithostrotion [Diphyphyllum] connorsensis EASTON, 1960, p. 579, text-figs. 11–14.
Diphyphyllum connorsensis (Easton). WILSON AND LANGENHEIM, 1962, p. 504, Pl. 86, figs. 3, 4.

Documentation.—LACMIP hypotype 8388. Three thin sections and 16 polished sections from one corallum from LACMIP loc. 1258 were studied.

Discussion.—This distinctive species previously has been reported (Easton, 1960; Wilson and Langenheim, 1962) only from White Pine County in east-central Nevada. Easton (1960, 1963) recorded the holotype from the base of the Arcturus Formation and the other specimens of the type series from the Riepe Spring Limestone and Riepetown Sandstone, as well as the Arcturus Formation. In the Egan Range, Wilson and Langenheim (1962) found this species only in the Riepe Spring Limestone, below the unit containing numerous cerioid corals including *Thysanophyllum princeps,* making it the lowest Permian colonial coral in the area. Its occurrence in the Lee Canyon section also is stratigraphically below that of *Thysanophyllum princeps.*

Subfamily THYSANOPHYLLINAE Hill, 1981
Genus THYSANOPHYLLUM Nicholson and Thompson, 1876
THYSANOPHYLLUM PRINCEPS (Easton, 1960)
Figure 6.5–6.6

Lithostrotion [Thysanophyllum] princeps EASTON, 1960, p. 576, text-figs. 5, 6.
Thysanophyllum princeps (Easton). WILSON AND LANGENHEIM, 1962, p. 514, Pl. 89, figs. 1, 2; WILSON, 1963, fig. 1.

Documentation.—LACMIP hypotype 8389. Three thin sections and eleven polished sections from one corallum from LACMIP loc. 1262 were studied.

Discussion.—This species previously has been reported (Easton, 1960; Wilson and Langenheim, 1962) only from east-central Nevada and west-central Utah in Lower Permian rocks. Easton (1960) reported it in several formations but later (Easton, 1963) modified some of the assignments so that the holotype was reported from the Riepe Spring Limestone and other specimens from that formation and the basal beds of the Arcturus Formation. Wilson and Langenheim (1962) found the species confined to the uppermost Riepe Spring Limestone in the Egan Range of east-central Nevada. The Spring Mountains occurrence also seems limited to a single stratigraphic position.

Stevens (1977) cited the genus as being present in east-central California and later (Stevens, 1982) discussed its significance to plate tectonic reconstructions. A species determination for the east-central California occurrence was not given.

Family Incertae sedis
Genus MCCLOUDIUS Wilson, 1982
MCCLOUDIUS PARVUS n. sp.
Figure 6.1–6.4

Diagnosis.—A species of *Mccloudius* characterized by the combination of small corallite diameters and few septa.

External description.—Corallum phaceloid, hemispheroidal, maximum observed diameter 4.5 cm; corallites to 11 cm diameter, touching to 0.5 cm apart; epitheca with prominent transverse wrinkles; calyx to 0.5 cm deep, with steep walls and central axial boss of conical shape to 0.2 cm tall, 0.1 cm wide at base.

Transverse section description.—Corallites circular to subcircular, diameters 6.5–11.0 mm; septa of two orders, 18–20 each, thin throughout or slightly dilate in tabularium; major septa 2–3 mm long, protruding 1–2 mm into tabularium, except some cardinal septa about 0.5 mm shorter, some counter septa attached to medial plate; minor septa generally entering tabularium as nubs or short spines in parts of all corallites; dissepimentarium to 5 mm wide, variable, regular in smaller corallites, becoming mostly lonsdaleoid in outer part of larger corallites; regular part of dissepimentarium with concentric, herringbone, and pseudoherringbone dissepiments; lonsdaleoid part of dissepimentarium may occupy one-half perimeter of corallite, containing 5–6 ranks of large, cystose, axially convex dissepiments; axial structure clisiophylloid, relatively large, 2–4 mm diameter, filling most of tabularium, consisting of medial plate (sinuous in some), crossed by 4–8 septal lamellae, connected by wide zone of axial lamellae that may touch septal ends; corallite wall 0.2–0.3 mm wide.

Longitudinal section description.—Dissepimentarium of 3–5 ranks of dissepiments, steeply inclined, generally small, globose; tabellae of two ranks, axial and periaxial; axial tabellae of 1–3 ranks, elongate, steeply dipping inward and upward to medial plate; periaxial tabellae of 1–2 ranks, steeply dipping inward and upward to axial tabellae; medial plate continuous, straight to sinuous.

Collections.—Holotype, LACMIP 8390, paratypes, LACMIP 8391–8393. Three thin sections and 13 polished sections from four coralla from LACMIP loc. 1274 were studied.

Discussion.—The peripheral ring of lonsdaleoid dissepiments clearly identifies this coral as a species of *Mccloudius.* Curiously, without the partly lonsdaleoid dissepimentarium, it would fit nicely into *Heritschioides,* near *H. buttensis* Stevens, 1967, as grouped by Wilson (1982, fig. 1). Some species of *Heritschioides* have a few lonsdaleoid dissepiments but none as many as *Mccloudius.*

Mccloudius fluvius Wilson, 1982, the type species, is the only other species referred to the genus. *Mccloudius parvus,* however, it nearly half the size in corallite diameters and has far fewer septa than *M. fluvius.*

Etymology.—The specific name is *parvus,* Latin, meaning small.

Subclass TABULATA
Milne-Edwards and Haime, 1850
Order AULOPORIDA Sokolov, 1947
Superfamily SYRINGOPORICAE de Fromentel, 1861
Family SYRINGOPORIDAE de Fromentel, 1861
Genus SYRINGOPORA Goldfuss, 1826
SYRINGOPORA MCCUTCHEONAE
Wilson and Langenheim, 1962
Figure 7.1–7.2

Syringopora mccutcheonae WILSON AND LANGENHEIM, 1962, p. 515, Pl. 89, fig. 11–13; LANGENHEIM AND LANGENHEIM, 1965, p. 236; WILSON, 1982, p. 83, figs. 48a, b.

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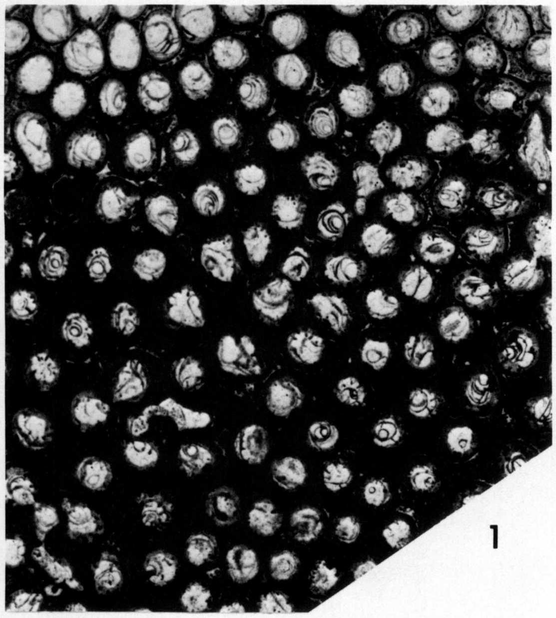
FIGURE 7—*1, 2, Syringopora mccutcheonae* Wilson and Langenheim, hypotype, LACMIP 8394. *1,* transverse section; *2,* longitudinal section. *3–5, Syringopora multattenuata* McChesney. *3,* transverse section, hypotype, LACMIP 8395; *4,* longitudinal section, hypotype, LACMIP 8396; *5,* longitudinal section, hypotype, LACMIP 8395. All figures ×3.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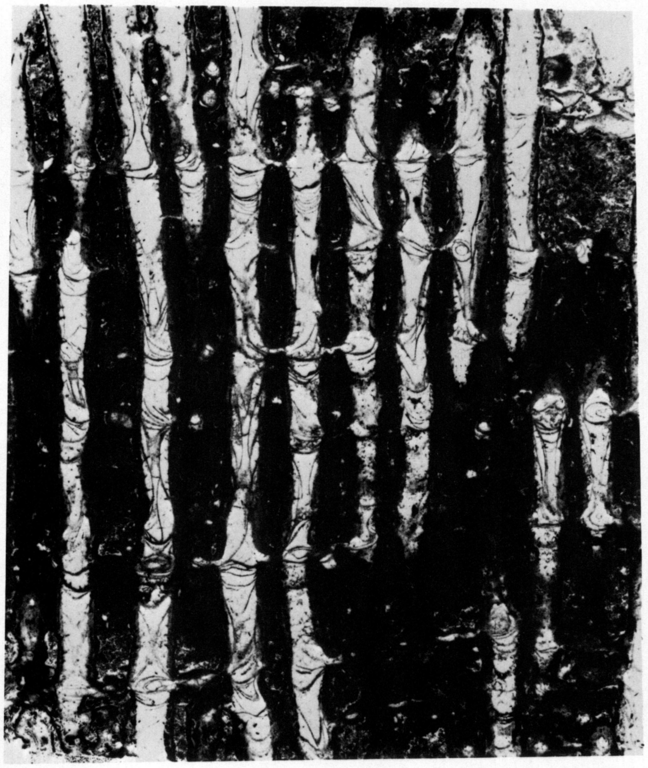
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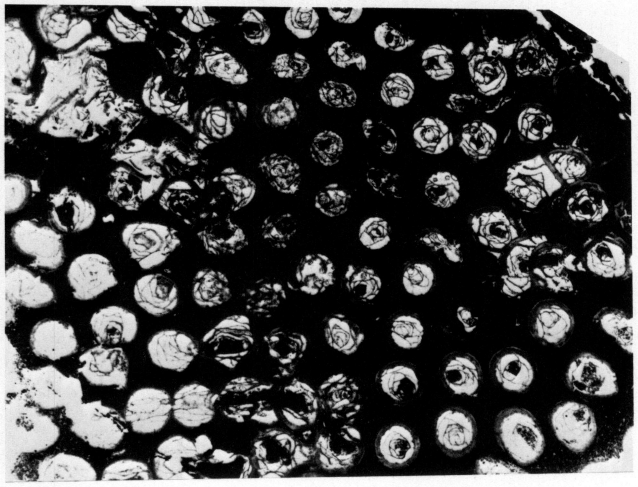
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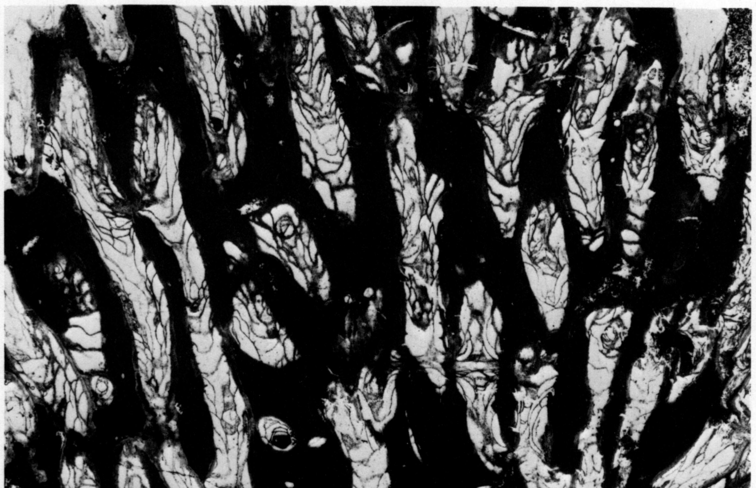

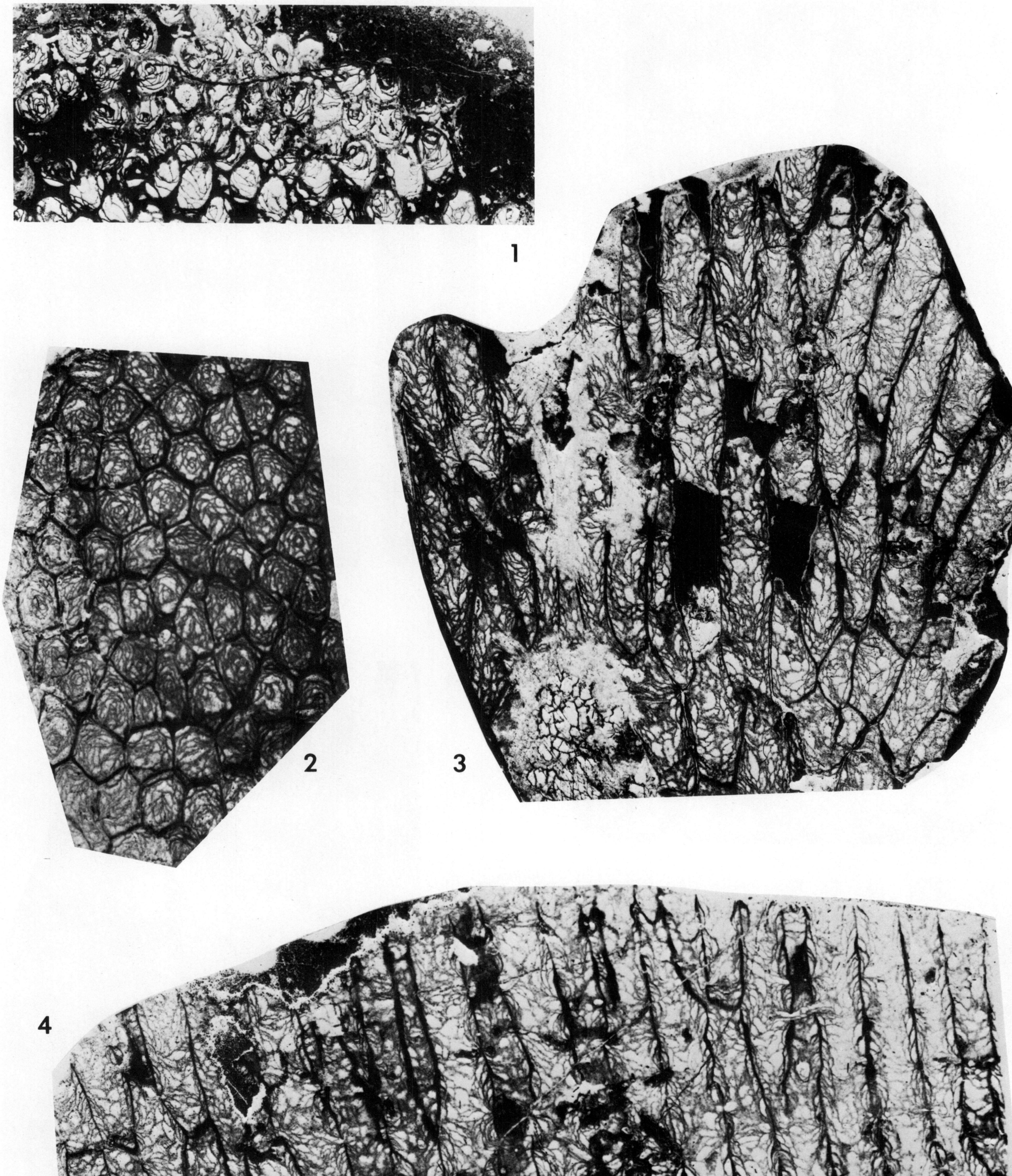
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Documentation.—LACMIP hypotype 8394. Six thin sections and 12 polished sections from two coralla from LACMIP loc. 1260 were studied.

Discussion.—The corallites of the specimens from the Spring Mountains are a little smaller in diameter than those listed for the type series. However, other characteristics, especially the occurrence of connecting processes in neighboring corallites at the same levels, are identical. A few corallites show traces of septal spinules in longitudinal and tangential longitudinal sections (Figure 7.2), arranged in a grid-like pattern, like some in the McCloud Limestone specimens. However, the preservation is variable in coralla from all localities so that apparent absence of them from the type specimens is not deemed to be a species character. The arrangement of the spinules is strongly reminiscent of those in the Lower Cretaceous coralline sponge *Acanthochaetetes seunesi* as figured by Wood (1990, fig. 7, top right) and suggests a future phyletic reassignment for the syringoporids.

This is the third record of this species in the Great Basin, where it seems to be everywhere associated with cerioid corals of Zone 1 of Easton (1960) and Zonule 2 of Wilson and Langenheim (1962). The occurrence of connecting processes at the same levels in neighboring corallites gives it a bamboo-like appearance readily recognized in the field, making it a potential index fossil.

SYRINGOPORA MULTATTENUATA McChesney, 1859
Figures 7.3–7.5, 8.1

Syringopora multattenuata MCCHESNEY, 1859, p. 75; MCCHESNEY, 1867, p. 2, Pl. 2, fig. 4; MCCUTCHEON, 1961, p. 1014, Pl. 121, figs. 1–8; WILSON, 1982, p. 83, figs. 48e–48f.

Documentation.—LACMIP hypotypes 8395, 8396 (LACMIP locs. 1255, 1257). Thirteen thin sections and polished sections from four coralla from LACMIP locs. 1255–1257 and 5645 were studied.

Discussion.—*Syringopora multattenuata* was redescribed and neotypes designated by McCutcheon (1961), who noted its wide distribution in the Upper Pennsylvanian (Missourian) to Lower Permian (Wolfcampian) formations in the midwestern and western United States and Spitsbergen. Wilson (1982) found the species in the McCloud Limestone in fusulinid zone D, Wolfcampian, of Skinner and Wilde (1965). It should be noted that in the McCloud Limestone and in the Bird Spring Formation of the Spring Mountains and the Arrow Canyon Range (Langenheim and Langenheim, 1965) definite *S. multattenuata* occurs stratigraphically below *S. mccutcheonae,* although Langenheim and Langenheim (1965) cited a *Syringopora* cf. *S. multattenuata* in the unit above *S. mccutcheonae* at Arrow Canyon. The distribution of these two species in the shelf and "terrane" faunas suggests a faunal association.

McCutcheon (1961, p. 1016), following Hill and Stumm (1956), considered that *Kueichowpora* (Chi, 1933) is an unwarranted generic concept because the axial tube, by which the genus largely is characterized, is "of specific significance only." The writer agrees with this conclusion, thereby retaining *Syringopora multattenuata* in the original genus rather than placing it in *Kueichowpora.* A thorough revision of syringoporid species with axial tubes might demonstrate that *Syringopora multattenuata* is a senior synonym of several other species and give this species a wider geographic distribution.

Family Incertae sedis
Genus CORNWALLATIA Hoare, 1966
CORNWALLATIA TABULARIA (Hoare, 1964)
Figure 8.2–8.4

Cornwallia tabularia HOARE, 1964, p. 502, Pl. 77, figs. 3–9.
Cornwallatia tabularia HOARE. HOARE, 1966, Pl. 17, fig. 1 (upper part).

Documentation.—LACMIP hypotype 8397. Three thin sections and 12 polished sections from one corallum from LACMIP loc. 1263 were studied.

Discussion.—This is the first record of *Cornwallatia* outside the type locality in the Lower Permian Sunflower Formation of Elko County, northern Nevada, where the coralla are intergrown with coralla of *Bayhaium,* another cerioid tabulate coral (Hoare, 1966). *Bayhaium* long was thought (Langenheim and McCutcheon, 1959; Hoare, 1966; Wilson, 1982) to be endemic to northern California–northern Nevada areas, but Ding and Yu (1984) extended the range to the Lower Permian of Shaanxi Province, China.

The Sunflower Formation is located in the Antler Highland carbonate province (plotted on Stewart, 1980, fig. 29) The Clark County occurrence of *Cornwallatia tabularia* is a significant faunal tie of this province with the predominately shelf coral faunas of the east.

Hill (1981) considered *Cornwallatia* to be a junior synonym of *Neosyringopora* Sokolov. I have considered them to be separate genera chiefly on the basis that *Cornwallatia* is essentially cerioid and *Neosyringopora* essentially fasciculate.

ACKNOWLEDGMENTS

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FIGURE 8—*1, Syringopora multattenuata* McChesney, transverse section, hypotype, LACMIP 8396. *2–4, Cornwallatia tabularia* (Hoare), hypotype, LACMIP 8397. *2,* transverse section; *3, 4,* longitudinal sections. All figures ×3.

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ACCEPTED 7 MARCH 1991

APPENDIX

LOCALITY REGISTER

The following localities are entered in the LACMIP locality register. They are in the Permian part of the Bird Spring Group, in a measured section that begins in the SW¼, SW¼, sec. 27, T17S, R57E as shown on the USGS topographic map of Charleston Peak, Nevada, 1957, 15 min., 1:62,500 and continues across strike, with some offsets to stay on ridge crests, through sec. 28 and the east ½, sec. 20, passing through VABM 6496 and ending with prominent fault in the saddle of the NE¼, NE¼, sec. 20. The line of section is shown in figure 2 of Rich, 1963, and an index map of the area in figure 1 of Rich, 1963. This has become known as the Lee Canyon Section after Lee Canyon, which lies to the south. The section begins with the occurrence of the lowest colonial rugose coral associated with large fusulinids, an association that indicates nearness to the base of the Permian throughout the Great Basin. Measured and collected by Edward Wilson and Larry Walters.

1255.—Limestone, medium to fine grained, dark gray weathers medium gray, beds 1–3 feet thick, no chert, series of steps, partly covered, attitude 230, 24°NE. Large scaphopods, abundant very large fasciculate rugose corals, syringoporid corals, fusulinids.

1256.—112 feet (34 m) above loc. 1255. Very large pelmatozoan columnals, abundant syringoporid corals, beds about 2 feet thick.

1257.—28 feet (8.5 m) above loc. 1256. Fusulinids, *Syringopora.*

1258.—186 feet (57 m) above loc. 1257. Thin-bedded gray limestone, no chert. Fasciculate rugose corals.

1260.—221 feet (67 m) above loc. 1258. Same lithology. *Syringopora.*

1262.—105 feet (32 m) above loc. 1260. Lowest cerioid coral seen. Top of ridge in the NE¼, SW¼, sec. 28.

1263.—Estimated 50 feet (15 m) below loc. 1262. Large coralla of cerioid syringoporid corals to 2 feet in diameter.

1264.—68 feet (21 m) above loc. 1262. Highest beds of limestone before a predominately sandy unit begins. Offset west across saddle in NE¼, SW¼, sec. 28 and begin measuring NW up ridge towards VABM 6496. Abundant *Omphalotrochus,* cerioid and fasciculate rugose corals, some syringoporids.

1268.—3,175 feet (968 m) above loc. 1264. Massive limestone cliff 15 feet (4.6 m) high with beds at top 1–3 feet thick and containing large fusulinids and masses of fasciculate corals. This is the limestone at the top of the predominately sandstone unit correlated by Barosh (1968) with the "Rib Hill" Sandstone of the Egan Range, White Pine County, Nevada. The loc. 1268 limestone and overlying thin-bedded sandstones were considered by Barosh (1968) to be equivalent to the Arcturus Formation of the Egan Range.

1274.—865 feet (264 m) above loc. 1268. Rare, small fasciculate corals. This is 570 feet (174 m) below the fault marking the top of the Lee Canyon section.

5645.—Peak across saddle due west of hill "5579" as shown in the NW¼, NW¼, sec. 27, T17S, R57E of the same map cited under loc. 1255. This is along strike from loc. 1255. Limestone, medium grained, dark gray weathers light gray, beds 1–2 feet thick, 15-foot-thick unit with fusulinids, lowest colonial rugose corals (very large fasciculate corals), abundant. Also abundant *Syringopora,* fusulinids. Attitude 355 24°NW.